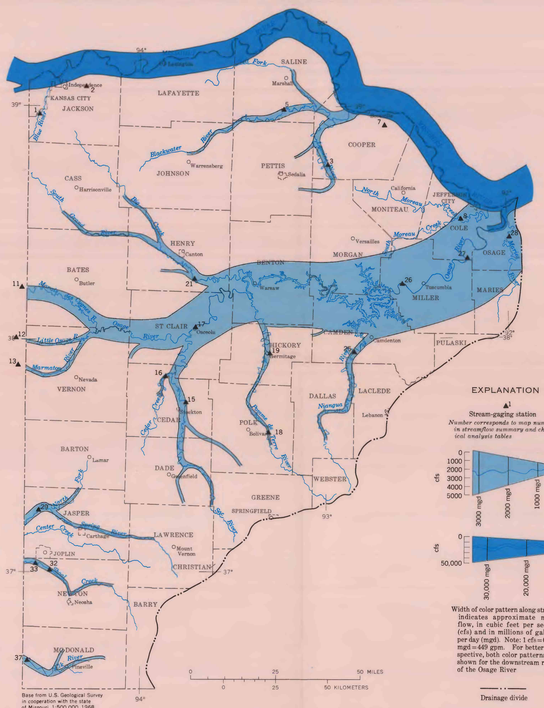
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES

HYDROLOGIC INVESTIGATIONS
ATLAS HA-491 (SHEET 3 OF 4)

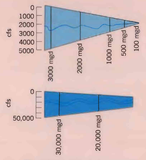
SURFACE–WATER AVAILABILITY



EXPLANATION

Stream-gaging station

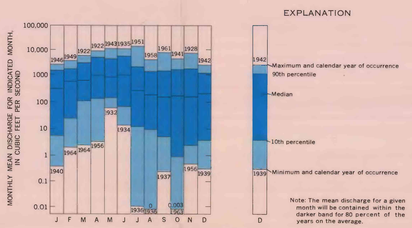
Number corresponds to map number in streamflow summary and chemical analysis tables



Width of color pattern along stream indicates approximate mean flow, in cubic feet per second (cfs) and in millions of gallons per day (mgd). Note: 1 cfs=0.646 mgd=449 gpm. For better perspective, both color patterns are shown for the downstream reach of the Osage River

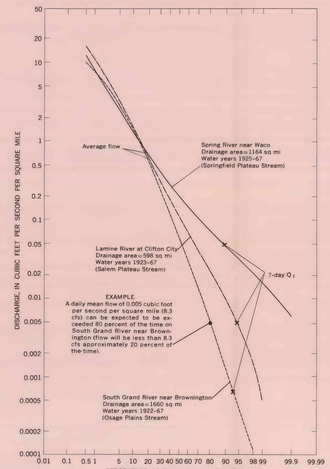
Drainage divide

THE UPPER LIMIT OF DEVELOPMENT OF A STREAM IS DETERMINED BY ITS MEAN FLOW.—*The unregulated flow of streams is less than the mean flow approximately 50 percent of the time (see flow-duration curves). Storage reservoirs are required for maximum utilization of surface-water supplies. Existing and authorized reservoirs in the area are shown on sheet 1.*



South Grand River near Brownington
water years 1922-69

THE UNREGULATED FLOW OF STREAMS IS HIGHLY VARIABLE.—*At the South Grand River near Brownington gaging station for example, the mean flow for the month of July has ranged from 0.01 cfs in 1936 to 13,500 cfs in 1951. Minimum monthly mean flows of most streams in the area occurred during the severe droughts of the 1930's, mid-1950's, and mid-1960's. Maximum monthly mean flows generally occurred during the 1920's and 1940's.*



TYPICAL FLOW-DURATION CURVES ILLUSTRATE DIFFERENT STREAMFLOW CHARACTERISTICS OF UNREGULATED STREAMS.—*The flow of unregulated streams on the Springfield Plateau in the southern part of the area (represented by Spring River near Waco) is better sustained during periods of little rain than is that of Osage Plains and Salem Plateau streams farther north (represented by South Grand River near Brownington and Lamine River at Clifton City). The better sustained flow of Springfield Plateau streams is due to the numerous springs in their basins that discharge ground water from storage in the Mississippian limestone of that area.*

Osage Plains streams are underlain by less permeable Pennsylvanian shale and sandstone and their flow is relatively poorly sustained during periods of little rain because ground-water storage in these rocks is small. Low-flow characteristics of Salem Plateau streams in the area are intermediate between those of Springfield Plateau and Osage Plains streams, with several well-sustained, spring-fed streams south of the Osage River but few springs and less well-sustained streams north of the Osage River.

REGIONAL DRAFT-STORAGE RELATIONS PROVIDE ESTIMATES OF STORAGE REQUIRED TO MAINTAIN VARIOUS DRAFT RATES FOR SELECTED CHANCES OF RESERVOIR DEFICIENCY.—*Draft rates are uniform. Storage estimates are not adjusted for reservoir sedimentation, evaporation, or seepage.*

Sedimentation rates may be estimated from sediment yield data on this sheet. Average annual lake evaporation varies rather uniformly from 46 inches in the southwest corner of the area to 34 inches in the northeast corner (National Weather Service 1959, pl. 3). Seepage losses are generally insignificant in the Osage Plains. Seepage losses are generally high on the flat uplands of the Springfield Plateau and are quite variable in the Salem Plateau. Careful study of the geologic setting is recommended for proposed reservoir sites in the Plateaus.

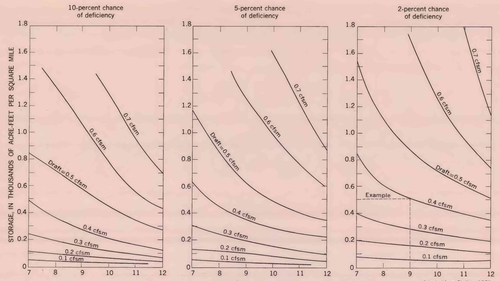
EXAMPLE OF USE OF GRAPHS

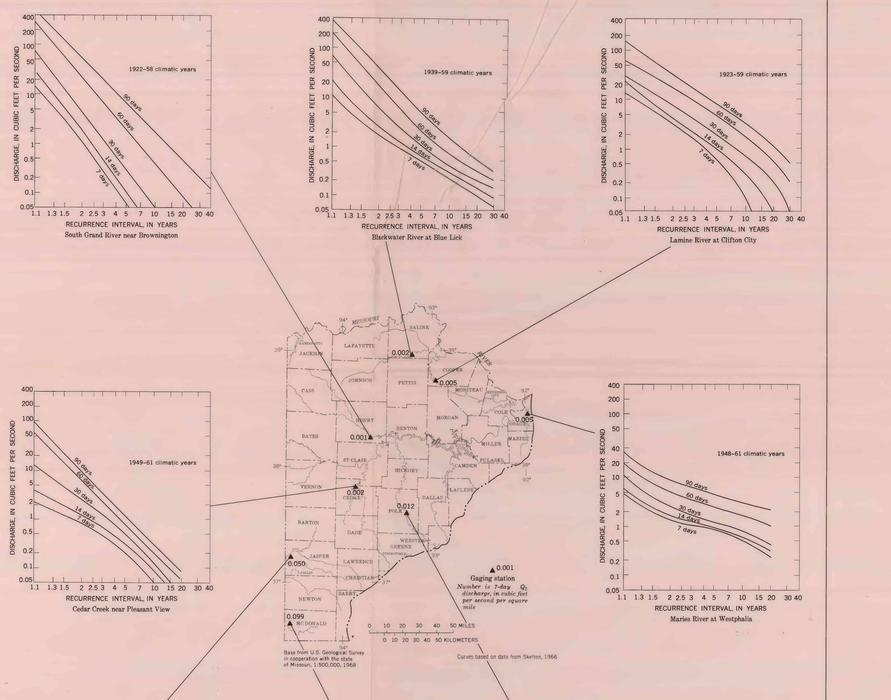
Assume that an estimate of storage is desired for a 2-percent chance of reservoir deficiency for a proposed reservoir site near the northeastern corner of Henry County. The desired draft rate is 0.2 cubic feet per second (90 gallons per minute or 145 acre-feet per year) and the drainage area of the proposed site is 0.5 square mile.

Solution

1. From the runoff map on sheet 1, the average annual runoff for the site is estimated to be 9 inches.
2. Enter the draft-storage relation for a 2-percent chance of deficiency with the average runoff of 9 inches. For the desired draft of 0.4 cubic feet per second per square mile ($\frac{0.2 \text{ cfs}}{0.5 \text{ square mile}} = 0.4$ cfsm), read the required storage to be 510 acre-feet per square mile or 510 x 0.5 = 255 acre-feet.

Note: This estimate of storage should be increased to allow for reservoir sedimentation, evaporation, and seepage.





SUMMARY OF STREAMFLOW DATA
For gaging stations shown on average discharge map

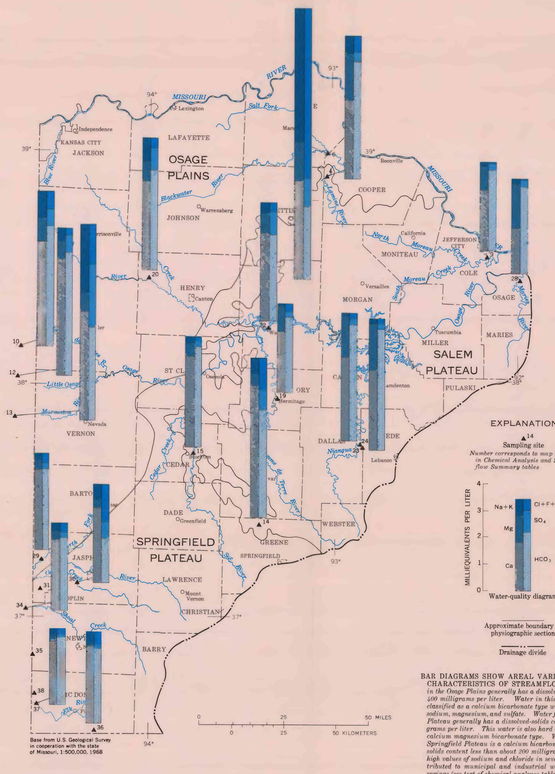
Map number	Station number	Station name	Drainage area (square miles)	Period of record (water years)	Discharge for period of record (cubic feet per second)			Average annual runoff for period of record (inches)
					Maximum	Minimum	Mean	
1	06893500	Blue River near Kansas City	188	1940-70	41,000	0	141	10.18
2	06894900	Little Blue River near Lake City	184	1949-70	9,460	0	124	9.15
3	06907000	Lamine River at Clifton City	598	1923-70	65,500	0	458	10.40
5	06908000	Blackwater River at Blue Lick	1,120*	1923-31,1939-70	54,000	0.1	711	8.62
7	06910000	Petite Saline Creek near Boonville	182	1949-67	6,120	0	88	7.21
9	06915500	Moreau River near Jefferson City	531	1948-56,1958-70	24,400	.1	364	8.81
11	06916600	Marais des Cygnes River near Kans.—Mo. State Line, Kans.[1]	3,230*	1959-70	57,400	0	1,920	8.06
12	06917000	Little Osage River at Fulton, Kans.	295	1949-70	26,300	0	191	8.79
13	06917500	Marmaton River near Fort Scott, Kans.	408	1922-24,1930-70	38,100	0	285	9.48
15	06919000	Sac River near Stockton*	1,160*	1925-70	120,000	0	969	11.35
16	06919500	Cedar Creek near Pleasant View	420*	1934-36,1949-70	33,900	0	281	9.08
17	06925500	Osage River at Osceola[2]	8,220*	1915-26,1931-70	146,000	3.6	6,100	8.42
18	06921000	Pomme de Terre River near Bolivar	225	1951-69	18,300	.1	169	10.20
19	06921500	Pomme de Terre River at Hermitage	655	1925-65	70,000	0	587	12.16
21	06922000	South Grand River near Brownington	1,660[3]	1922-70	63,900	0	1,658	8.66
25	06924000	Niangua River near Decaturville	627	1939-67	33,400	6	627	13.57
26	06926000	Osage River near Bagnell[2]	14,000*	1881-1970	220,000	183	9,541	9.25
27	06926500	Osage River near St. Thomas[2]	14,500*	1932-70	216,000	346	9,816	9.19
28	06927000	Maries River at Westphalia	207	1948-70	26,100	.1	211	11.15
29	07186000	Spring River near Waco	1,164	1925-70	103,000	4.2	812	9.48
32	07187000	Shoal Creek above Joplin	427*	1942-70	62,100	12	373	11.86
33	07187500	Shoal Creek near Joplin[4]	439	1924-41	54,000	1.5	386	11.94
37	07189000	Elk River near Tiff City	872	1948-70	137,000	5.1	727	11.79

*Approximately.
[1]Natural flow affected by operation of Pomona Reservoir, wildlife refuge ponds, and irrigation diversions above station.
[2]Flow regulated by Stockton Reservoir after December 12, 1969.
[3]Low and medium flow regulated by upstream power plant.
[4]Flow regulated by Pomme de Terre Reservoir after 1960.
[5]Flow regulated by Lake of the Ozarks after 1931.
[6]At site used prior to July 21, 1966, 410 square miles.
[7]Low flow regulated by power plant prior to April 15, 1941.
[8]Minimum daily.

LOW-FLOW FREQUENCY CURVES INDICATE MINIMUM AVERAGE FLOW EXPECTED TO OCCUR FOR SELECTED PERIODS.—*The 7-day Q_2 discharge (minimum average flow for a 7-day period expected to occur at average intervals of 2 years) is zero for unregulated streams in the Osage Plains with drainage areas less than about 200 square miles. In comparison, the 7-day Q_2 discharge for a Springfield Plateau stream with a drainage area of 200 square miles will be within the range of 20 to 60 cfs. The flow of unregulated streams is less than the 7-day Q_2 discharge 5 to 10 percent of the time (see flow-duration curves). No flow for several days has occurred on most streams in the Osage Plains.*

Low-flow characteristics of streams are related to seasonal variations in ground-water levels in the three physiographic sections (see typical well hydrographs on sheet 1). In the Osage Plains where little seasonal response is shown in ground-water levels, 7-day Q_2 discharge of streams ranges from 0 to 0.001 cfsm (cubic foot per second per square mile). The seasonal response of ground-water levels is greater in the Salem Plateau and the 7-day Q discharge ranges from 0.01 to 0.07 cfsm. The greatest seasonal variation in ground-water levels occurs in the southern part of the Springfield Plateau, where the 7-day Q_2 discharge ranges from 0.10 to 0.22 cfsm.

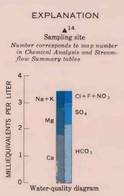
SURFACE–WATER QUALITY



EXPLANATION

Sampling site

Number corresponds to map number in Chemical Analysis and Streamflow Summary tables



Approximate boundary of physiographic section

Drainage divide

BAR DIAGRAMS SHOW AREAL VARIATION IN CHEMICAL CHARACTERISTICS OF STREAMFLOW.—*Water from streams in the Osage Plains generally has a dissolved-solids content less than 500 milligrams per liter. Water in this area is hard and may be classified as a calcium bicarbonate type with significant amounts of sodium, magnesium, and sulfate. Water from streams in the Salem Plateau generally has a dissolved-solids content less than 300 milligrams per liter. This water is also hard and may be classified as a calcium magnesium bicarbonate type. Water from streams in the Springfield Plateau is a calcium bicarbonate type with a dissolved-solids content less than about 300 milligrams per liter. Unusually high values of sodium and chloride in several of the diagrams is attributed to municipal and industrial waste effluent or to saline springs (see text of chemical analyses table).*

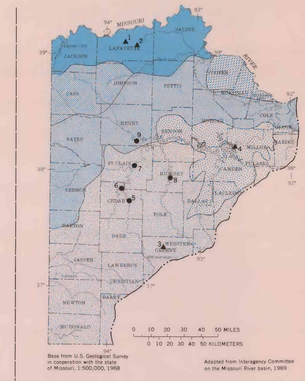
CHEMICAL ANALYSES OF SURFACE WATER

The magnitude of most water-quality parameters varies with the flow of the stream and with the season of the year. Analyses shown are representative of the quality of water in streams during periods of low flow, with the exception of Moreau River (No. 9), and do not reflect the range in concentrations that might be expected to occur at each site. Mineralization will be less at higher flows because of dilution. Noteworthy among streams affected by municipal or industrial waste effluent are Blackwater River (No. 6), Marmaton River (No. 13), Little Sac River (No. 14), Center Creek (No. 20), and Turkey Creek (No. 31). Blackwater River also receives highly mineralized water from several saline springs in its basin. Several streams, particularly Moreau River (No. 9) and Maries River (No. 28), appear to be affected by animal wastes. The low dissolved-oxygen content of streams in the Osage Plains suggests relatively high organic loads and poorly aerated streams in that area. The low dissolved-oxygen content of Sac River (No. 15) is attributed to releases of water of low dissolved-oxygen content from Stockton Reservoir. An analysis for Bennett Spring (No. 23) is included to illustrate the similarity of water-quality characteristics of springs and streams in the Plateaus. Analyses were made by the U.S. Geological Survey and the Missouri Water Pollution Board.

Map number	Station number	Stream and location	Date of collection	Discharge (cfs)	Temperature (°C)	Milligrams per liter: Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Organic and ammonia nitrogen as N	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphorus as PO_4	Chemical oxygen demand	Dissolved solids (residue at 180° C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25° C)	pH	Color	Turbidity, as SiO_2 (mg/l)	Dissolved oxygen: Milligrams per liter	Dissolved oxygen: Percent saturation	Colonies per 100 milliliters: Fecal Streptococci	Colonies per 100 milliliters: Fecal Coliform
4	06907300	Lamine River near Pilot Grove, Mo.	9-8-70	46	28	—	—	—	58	21	16	2.8	<0.1[1]	261	17	15	<0.1	<0.4	0.1	5	—	234	16	440	8.3	—	—	8.2	104	20	40
6	06908700	Blackwater River at Nelson, Mo.	9-8-70	27	27	—	—	0.8	73	18	110	8.4	4	166	59	220	<.1	4.0	.4	8	—	254	118	900	7.9	10	—	6.9	86	1,600	1,700
9	06910800	Moreau River at Jefferson City, Mo.	10-15-70	228	15	—	—	Med.	<.5	45	11	3.2	2.4	<.1	183	12	.5	<.1	1.2	.2	10	—	166	6	330	7.8	22	—	9.0	88	7,000	3,400
10	06916000	Marais des Cygnes River at Trading Post, Kans.	8-13-70	33	27	8.5	0	.07	78	11	19	3.0	.74	272	40	16	.3	2.4	.28	13	315	240	16	533	7.9	7	21	3.8	48	140	10
12	06917000	Little Osage River at Fulton, Kans.	8-13-70	14	25	9.1	0	.13	87	7.9	9.6	2.3	.86	280	31	7.8	.3	2.0	.32	16	309	250	20	496	7.9	9	34	3.3	40	400	60
13	06917500	Marmaton River near Fort Scott, Kans.	8-13-70	26	27.5	9.4	0	.44	81	8.8	54	5.7	1.2	212	110	50	.6	2.8	.58	36	452	238	64	718	7.6	11	25	4.5	57	250	75
14	06918600	Little Sac River near Walnut Grove, Mo.	9-23-69	8.2	17	—	—	—	98	5.5	15	4.4	2[1]	344	36	24	<.1	20	3.5	—	—	266	66	525	7.9	8	—	7.0	72	1,400	200
15	06919000	Sac River near Stockton, Mo.[2]	8-10-70	30	21	—	—	—	68	6.3	4.3	3.2	1.6[1]	229	10	4.5	<.1	—	.6	16	—	196	8	390	7.3	—	—	2.8	31	1,000	60
19	06921500	Pomme de Terre River at Hermitage, Mo.[3]	8-31-70	29	26	—	—	—	45	12	2.0	.5	1.0[1]	146	<10	7.5	<.1	.9	.1	5	—	140	20	300	8.7	8	—	8.6	105	90	<10
20	06921600	South Grand River at Urich, Mo.	9-1-70	1.4	26	—	—	—	67	8.8	20	2.6	1.0[1]	227	40	7.5	<.1	<.4	.2	20	—	204	18	460	7.7	10	—	3.8	41	500	600
22	06922510	Osage River below Warsaw, Mo.[4]	9-1-70	—	30	—	—	—	65	9.2	9.4	1.5	.9[1]	193	40	7.5	<.1	<.4	.3	20	—	200	40	400	8.6	6	—	8.6	113	<10	<10
23	06923500	Bennett Spring at Bennett Springs, Mo.	8-31-70	95	14	—	—	—	60	21	2.5	0	1.1[1]	276	<10	3.0	<.1	4.9	.4	10	—	238	12	490	7.8	0	—	7.2	69	410	120
24	06927700	Niangua River at Bennett Springs, Mo.	8-31-70	126	19	—	—	—	62	19	1.8	1.2	1.0[1]	264	<10	3.0	—	4.9	.1	3	—	236	12	425	8.0	0	—	9.3	99	—	—
28	06927000	Maries River at Westphalia, Mo.	9-23-69	11	22	—	—	—	94	20	.5	1.5	.1	197	12	<.1	<.1	4.4	.1	—	—	168	6	315	7.9	2	—	7.8	89	2,500	710
29	07186000	Spring River near Waco, Mo.	8-14-69	71	25	11	0	.05	60	4.0	6.6	1.9	.39	184	9.8	7.0	.1	5.9	.80	0	212	166	15	344	8.2	5	20	6.0	72	800	120
30	07186400	Center Creek near Carterville, Mo.	8-11-70	33	25.5	11	.03	0	56	3.5	14	1.6	7.9	100	31	12	.8	58	1.0	3	262	154	72	385	6.9	6	6.4	5.0	52	2,100	95
31	07186500	Turkey Creek near Joplin, Mo.	8-11-70	12	24.5	13	.13	.08	87	6.2	41	6.4	2.0	191	110	39	.5	22	5.8	22	430	243	86	666	7.6	11	2.8	5.1	61	750	16,000
34	07187500	Shoal Creek near Neosho, Mo.	8-14-70	95	25	9.9	.02	0	53	3.5	6.1	1.5	.38	166	10	6.1	.1	5.4	.67	4	181	147	10	310	7.9	5	7.9	6.2	75	260	220
35	07188500	Lost Creek at Seneca, Mo.	10-9-69	6.6	18	11	.02	.03	51	1.9	3.3	1.5	.09	152	5.8	2.6	0	6.0	.06	3	160	135	10	278	7.6	5	5.6	11	114	360	150
36	07188620	Little Sugar Creek at Caverna, Mo.	10-9-69	12	17	9.7	.11	.04	57	1.8	6.8	2.3	.08	170	5.4	18	.1	1.8	.28	0	176	150	10	313	7.6	5	6.9	8.4	86	90	46
37	07189000	Elk River near Tiff City, Mo.	10-9-69	85	18.5	10	.03	.02	47	2.8	4.3	1.8	.07	154	4.8	5.8	.1	2.5	.06	3	154	129	2	275	7.5	12	3.5	9.3	98	170	<1
38	07189100	Buffalo Creek at Tiff City, Mo.	9-5-69	3.2	21	11	0	0	50	1.6	4.0	1.8	.05	159	6.2	5.4	.1	2.8	.06	0	165	132	8	266	7.7	5	7.0	7.6	84	220	—
		Maximum		228	30	13	.13	.8	98	21	110	8.4	7.9	280	110	220	.8	58	5.8	36	452	266	118	900	8.7	22	94	11	114	7,000	16,000
		Minimum			1.4	14	8.5	0	0	34	1.6	.5	0	.03	100	4.8	<.1	0	<.4	.06	6	154	129	2	266	6.9	0	2.8	2.6	31	<10	<1
		Median			29	25	10	.02	.05	60	8.4	6.7	2.1	.38	188	12	7.5	<.1	2.8	.29	6	212	198	16	395	7.9	6	7.0	7.1	80	400	110

[1]Ammonia nitrogen only. Not included in computation of median.
[2]Station located about 0.5 mile downstream from Stockton Reservoir.
[3]Station located about 9 miles downstream from Pomme de Terre Reservoir.
[4]Station located near upstream end of Lake of the Ozarks.

HORIZONTAL GRAPHS SUMMARIZE THE VARIATION OF SELECTED WATER-QUALITY PARAMETERS FOR SAMPLING SITES SHOWN IN TABLE.—*Water samples were collected during water years 1966-70. The number of samples collected at each site during this period ranged from 1 to 38 with a median of 11. The range indicated for each parameter was probably exceeded at most sites during the period. Comparison of the above graphs for the three physiographic sections indicates that water in natural streams in the Osage Plains is more highly mineralized and that concentrations are more variable there in the other two sections. Sulfate concentrations are also much lower in Plateau streams where Pennsylvanian rocks are absent. Streams that receive significant quantities of waste effluent in each section have unusually high values for some parameters such as specific conductance and sulfate. (Number 31, for example.)*



SUMMARY OF SEDIMENTATION DATA

Index number	Sediment station or reservoir	Drainage area (sq mi)	Average annual sediment yield (tons per sq mi)
1	Huscher	0.18	3,500
2	Higginsville Upper	2.65	2,515
3	McDaniel Lake	41.5	703
4	Lake of the Ozarks	13,900	598
5	Sac River near Stockton	1,160	142*
6	Cedar Creek near Pleasant View	420	220*
7	Osage River at Osceola	8,220	378*
8	Pomme de Terre River at Hermitage	655	292*
9	South Grand River near Brownington	1,660	493*

*Based on period 1948-63.

GENERALIZED ESTIMATES OF AVERAGE ANNUAL SEDIMENT YIELD ARE USEFUL IN THE PRELIMINARY DESIGN OF WATER RESOURCES PROJECTS.—*Sediment yields are highest in the northern part of the area where loessial soils are more abundant. The values shown are not considered reliable for drainage areas less than 100 square miles. Sediment yields from small drainage areas are extremely variable depending on such factors as soils, topography, vegetation, and land use. For estimates of sediment yield from small drainage areas, a detailed field reconnaissance by qualified personnel is recommended.*

WATER RESOURCES OF WEST–CENTRAL MISSOURI

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Missouri Geological Survey and Water Resources

1974

Interior–Geological Survey, Reston, Va.–1974